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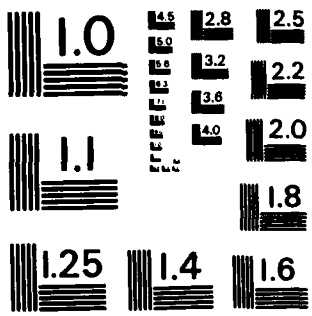

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THESIS ABSTRACT

THE OHIO STATE UNIVERSITY
GRADUATE SCHOOL
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NAME: Corinne Kraft McNamee

QUARTER/YEAR: Summer, 1983

DEPARTMENT: Department of Home Economics

DEGREE: M.S.

TITLE OF THESIS:

TIME AND TEMPERATURE CONDITIONS DURING PRODUCT FLOW AND SENSORY QUALITY OF POTATO SALAD PREPARED IN A CONVENTIONAL FOODSERVICE SYSTEM

Summarize in the space below the purpose and principal conclusions of your thesis.

The purpose of this descriptive study was to identify phases in product flow in a conventional foodservice system; to identify actual time and temperature conditions relative to phases in product flow; to identify critical control points relative to time and temperature standards; and to evaluate the sensory quality of potato salad prepared in a conventional system. Potato salad was selected for study because it presents a potential microbial hazard.

The phases in product flow were identified. Actual time-temperature conditions during refrigerated storage of prepared potato salad and during display and service of the salad did not meet food safety standards. Four critical control points were identified: refrigerated storage of cooked potatoes, refrigerated storage of prepared potato salad, display and service of potato salad, and holding time at room temperature. Sensory appearance overall, textural quality overall, and sensory quality overall were scored 35.00, 41.06, and 40.23 respectively on a scale of 0-60.

High ambient refrigerator temperatures, the excessively long time ingredients were held at room temperature, and failure to follow the standardized recipe were the major findings and are considered important for control in foodservice systems.

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Adviser's Signature

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TIME AND TEMPERATURE CONDITIONS DURING PRODUCT FLOW AND SENSORY QUALITY OF POTATO SALAD PREPARED IN A CONVENTIONAL FOODSERVICE SYSTEM

A Thesis

Presented in Partial Fulfillment of the Requirements
for the Degree Master of Science

by

Corinne Kraft McNamee, B.S.

The Ohio State University
1983

Approved by

Adviser
Department of Home Economics

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CHAPTER I

INTRODUCTION

Background

Since the 1960s hospital foodservice managers have experienced revolutionary changes in methods of processing meals for patients (Matthews, 1982c). Prior to the 1960s, hospital foodservice managers purchased the raw food and supervised the daily cooking operation in their own facilities. Technological innovations during the 1960s and 1970s led to the development of alternate food production systems in which food could be prepared days or weeks ahead of time and stored until needed; or prepared in great quantities in one central facility miles away from the multiple delivery points where it may be finally served; or purchased fully prepared and simply portioned, reheated, and served (Unklesbay et al., 1977). The alternate food production systems were developed to control the problems of rising labor and energy costs, low worker productivity, and inefficient use of foodservice equipment experienced with the traditional foodservice "from scratch" systems.

There are four major types of foodservice systems in operation today: modern conventional, commissary, ready-prepared, and assembly-serve systems (Unklesbay et al., 1977). Of these four, the commissary,

ready-prepared, and assembly-serve systems incorporate major advances in technology, engineering, and design concepts developed since the 1960s (Hysen and Harrison, 1982).

Unklesbay et al. (1977) described the four foodservice systems as follows. The modern conventional systems may incorporate a wide variety of convenience and some fully prepared foods. Although all food is not necessarily cooked "from scratch", food is still prepared on-premises to be served that same day. The commissary foodservice system is a centralized food procurement and production facility from which prepared food is distributed to several remote sites for final preparation and service. There are two types of ready-prepared systems: cook-chill and cook-freeze. In both systems foods are prepared and stored (either preplated or in bulk) from one day to several weeks before they are reheated and served. In the assembly-serve foodservice systems, fully prepared food that requires only storage and assembly before reheating at point of service is used.

Many hospital foodservice directors initially believed that the technologically advanced systems--the ready-prepared, commissary, or assembly-serve systems--would solve the problems of high labor cost, shortage of skilled labor, and low productivity experienced with the conventional foodservice systems (Rinke, 1976). However, research on the new systems has shown that there are some new problems to solve.

Donaldson (1971) stated that a major problem in the new systems is in developing new heat-conditioning equipment. Rinke (1976) described in detail some of the problems encountered in

establishing a ready-prepared, assembly-serve or commissary foodservice system. He stated the most serious drawback of the ready-prepared system is the high cost of modifying and testing recipes for items such as sauces and gravies which do not have freeze-thaw stability when prepared by conventional procedures. Rinke (1976) saw the utility of the assembly-serve systems as limited, especially in hospitals, because there is still, even now, only a limited variety of modified diet convenience foods available for purchase. According to Rinke (1976), quality controls including microbiological audits must be very precise in all of the three new systems because of longer storage or holding times between cooking and service, and some skilled labor is still required.

More recently, additional problems with the new foodservice systems have been described by other investigators (Cremer, 1981; Cremer and Chipley, 1980a, 1979, 1977). Some of the problems encountered in the new foodservice systems include: (1) the lack of an adequate, consistent, controlled voltage supply for both chill and heat equipment; (2) equipment which is inadequate to heat or cool food to temperatures effective for microbiological safety; (3) difficulty in maintaining uniform portion size; (4) difficulty in controlling portion placement to ensure adequate reheating; (5) difficulty in achieving minimal holding of food at room temperature during and between the many additional phases of food product flow in these more complex handling and distribution systems; and (6) difficulty in prevention of contamination of food by equipment and food handlers.

This recent research points out that although we now have much more technologically sophisticated equipment and methods available to control the problems of rising costs, there are still some major equipment and personnel management problems to be resolved to ensure that the food product will be palatable and microbiologically safe. Supporting this view of the role of management control, Matthews (1982b) pointed out that regardless of the type of foodservice system in use, the ramifications of process steps, time and temperature relationships, personnel, and equipment on the quality and safety of food must not be left to chance but must be controlled by management.

Bobeng and David (1977) recommended implementation of the hazard analysis critical control point (HACCP) concept for foodservice operations as a control device managers could use to eliminate a microbiological hazard and control quality. The work of Bobeng and David (1977) and Matthews (1982b) on implementation of the HACCP concept shows that management control of time and temperature standards at each process step is an essential factor in maintaining food quality and microbiological safety.

Problem Statement

In the rush to make foodservice operations more efficient and productive, managers have too frequently concentrated their efforts solely on reducing or controlling costs while sensory and microbial quality of the food produced have received inadequate emphasis (Unklesbay et al., 1977). There is limited published data on the effects of changing methods of preparation, storage, and service on

the sensory and microbial quality of meals served in the new foodservice systems. There is even less published data on the sensory and microbial quality of meals served in the traditional or modern conventional foodservice system. According to Unklesbay et al. (1977), there is a strong need to investigate the effects of the various methods of food procurement, storage, preparation, and service upon the microbial, nutritional, and sensory qualities of menu items produced in all four types of foodservice systems, since they will all probably continue to be used for the foreseeable future.

The conventional foodservice system is still used by about 80 percent of hospitals according to a report by Business Communications Co., Inc. (1977) cited by Matthews (1982a). In spite of the long history and widespread use of the conventional foodservice system, research to determine the sensory quality of food or to identify the critical factors, such as time and temperature of holding, in producing food of high sensory and microbial quality has been limited. Sensory and microbial quality of food in conventional foodservice systems may be related to time and temperature conditions during process steps (Glew, 1970).

The purpose of this study is to identify and define phases in product flow in a conventional system; to identify actual time and temperature conditions in relationship to phases in product flow; to identify critical control points in relationship to the work of other researchers; and to describe the sensory quality of a food product prepared in a conventional foodservice system.

Potato salad was selected for study because it presents a potential microbial hazard (Fowler and Clark, 1975; Longree et al., 1959; Longree, 1982; Pace, 1975; Silverman et al., 1975a, 1975b). Bauman (1974) stated that sensitive ingredients such as eggs in a mixed food product can have a pronounced effect on food safety. Pasch (1974) cited fresh, uncooked produce as a frequent source of pathogenic microorganisms. Cremer and Chipley (1980) identified the source of post-cooking contamination of roast beef slices to be employees handling the food product without gloves. Use of eggs and fresh produce as ingredients, and employee handling of the food product are three possible sources of microbial contamination in potato salad.

The specific objectives of this study were to provide answers to the following questions:

1. What are the phases in product flow in the preparation of potato salad in a conventional foodservice system?

2. Do actual time and temperature conditions during preparation and service of potato salad in a conventional system conform to time and temperature standards?

3. Using time and temperature standards, what are the critical control points in the preparation of potato salad in a conventional foodservice system?

4. What are some characteristics that determine the quality of potato salad?

5. What is the sensory quality of potato salad prepared in a conventional foodservice system?

Definition of Terms

Phases of food product flow - the alternate paths within foodservice systems which food components and menu items may follow, initiating with receipt of food and ending with serving the food to the client (Unklesbay et al., 1977).

Critical control point - any processing point where loss of control would result in food safety risk related to time and temperature standards (Matthews, 1982b).

Time and temperature standards - (a) all potentially hazardous foods requiring cooking should be cooked to heat all parts of the food to a minimum temperature of 140^{o}F; (Exceptions are listed for poultry, poultry stuffings, stuffed meats, meats containing stuffing, pork, rare roast beef and rare beef steak.) (b) potentially hazardous food requiring refrigeration should be cooled rapidly to an internal temperature of 45^{o}F or below so that the cooling period does not exceed four hours; (c) potentially hazardous food to be served chilled should be kept at an internal temperature of 45^{o}F or below during display and service (HEW, 1978).

Potentially hazardous food - any food that consists in whole or in part of milk or milk products, eggs, meat, poultry, fish, shellfish, edible crustacea, or other ingredients, including synthetic ingredients, in a form capable of supporting rapid and progressive growth of infectious or toxigenic microorganisms (HEW, 1978).

CHAPTER II

REVIEW OF THE LITERATURE

In the past twenty years the microbial and sensory quality of food produced in the alternate foodservice systems has received limited attention while foodservice operators and researchers have focused their efforts on controlling costs, increasing worker productivity, and using equipment more efficiently (Unklesbay et al., 1977).

In this chapter the alternate foodservice systems are defined. This chapter also includes reviews of published data on the following: microbiological hazards in the alternate foodservice systems; the hazard analysis critical control point (HACCP) concept; the validity of implementing time and temperature controls at each critical control point to monitor microbial and sensory quality of food; the potential microbial hazard of potato salad; and sensory evaluation data of food produced in some of the alternate foodservice systems.

Types of Foodservice Systems

Unklesbay et al. (1977) described the four major types of institutional foodservice systems in operation in the United States today: modern conventional, commissary, ready-prepared, and assembly-serve. The modern conventional foodservice system is still

characterized by the preparation of food in an on-premises kitchen with preparation as near to service time as possible.

Unklesbay et al. (1977) characterized the commissary system as having centralized food procurement and production functions with distribution of food to several remote sites for final preparation and service. The commissary foodservice systems are also known as satellite, commissariat, central commissary or food factory systems.

According to Unklesbay et al. (1977) there are two types of ready-prepared food systems: cook-freeze and cook-chill. In both types of systems, foods are prepared largely on-premises on a convenient schedule determined by the foodservice manager from one day to several weeks before service. In the cook-chill system, cooked food is usually chilled in bulk, refrigerator stored from one to several days, plated, chilled again, and reheated prior to service. In the cook-freeze system, cooked food is usually preplated, frozen, and freezer stored for up to three months prior to service. Reheating may be accomplished by microwave, convection, or integral heat systems.

Fully processed foods are used exclusively in the assembly-serve food system (Unklesbay et al., 1977). Frozen entrees are purchased either in bulk, preportioned, or preplated. They requiie only storage and assembly before reheating at the point of service. Reheating may be accomplished by microwave, convection, or integral heat systems.

The commissary, ready-prepared, and assembly-serve foodservice systems have been referred to as high technology systems because

they incorporate major advances in technology, engineering, and design concepts (Hysen and Harrison, 1982). The rationale for implementing any of the high technology systems to replace the conventional foodservice system has been primarily to control the high costs encountered in the traditional conventional foodservice system where equipment and personnel were not used to maximum efficiency (Matthews, 1982c).

Microbiological Hazards

Cremer (1981) studied the variability in temperature of scrambled eggs prepared in a cook-chill hospital foodservice system where the scrambled eggs were cooked, chilled, held, and reheated in microwave ovens at the point of service. This author concluded that in order to ensure desirable temperatures for microbial safety in this type of cook-chill, microwave reheat system the following factors must be controlled: (a) adequate voltage must be supplied for effective oven operation, (b) voltage must be rigidly controlled within the operating system, (c) portions must be accurately controlled by weight, (d) a very narrow range of refrigerator temperatures during the chill phase must be maintained, and (e) for total system effectiveness there is a need to ensure optimum power is consistently available for both the chill and reheat equipment.

Cremer (1981) noted that since the rate of destruction of microorganisms is mathematically related to the time of exposure, the short heating time in microwave ovens is of concern. Crespo and Ockerman (1977) found that microwave heating to the same internal end-point temperatures was less effective than conventional heating

in destroying microorganisms. Crespo et al. (1977) showed that some microorganisms are less sensitive to heat in a microwave oven compared to a conventional oven.

In a study of roast beef prepared in a cook-chill foodservice system, Cremer and Chipley (1980a) indicated that food safety and effective operation of this type of cook-chill, microwave reheat system was dependent on: (1) thorough cooking and reheating of food; (2) controlled rate of cooling food after cooking; (3) prevention of contamination of food by equipment and foodhandlers; and (4) minimal holding of food at room temperature during processing and transportation. Selection of heating equipment with adequate power, routine check of actual power, and uniformity in portion size, composition, and placement were cited as factors in ensuring thorough cooking and reheating of food. To control the rate of cooling it was considered essential to select refrigeration equipment which has the capacity to cool the required volume of food in an appropriate period of time (Cremer and Chipley, 1980a). Sanitizing equipment and having employees wear gloves to handle foods were cited (Cremer and Chipley, 1980a) as factors in reducing contamination.

In their evaluation of the microbial safety of precooked frozen hamburger patties used in a school foodservice commissary system, Cremer and Chipley (1977) indicated the need for careful monitoring of the product as purchased, as handled within the operating system, and especially, as heated for service. They identified two key areas requiring control in this type of foodservice system: (a) preventing

microbial buildup during assembly, and (b) careful monitoring of internal temperatures during reheating.

Cremer and Chipley (1979) also studied microbial quality of meatloaf prepared in a commissary system that supplied meals to the elderly. The authors recommended thorough cooking of meat prior to assembly, the use of good foodservice practices to prevent recontamination during refrigerated storage, and thorough reheating of meat loaves for assembly.

Development of the HACCP Concept

Bauman (1974) described the hazard analysis critical control point (HACCP) concept that was first developed by the food processing industry as a rational, logical process of estimating the risk associated with processing and marketing a given food product. Bauman (1974) defined hazard analysis as the identification of sensitive ingredients, critical process points, and relevant human factors as they affect food product safety.

Sensitive ingredients includes: (a) any food product that has been identified as a significant factor in salmonellosis, (b) a manufacturing process which does not include a controlled step that would destroy salmonella, or (c) a substantial likelihood for microbial growth if the product is mishandled or abused in distribution or consumer usage (Bauman, 1974).

Bauman's (1974) description of critical process points includes both biological and physical hazards. Bauman (1974) advocated three steps for control of process points: (1) delineation of all physical

systems, identifying hazards to food safety, (2) elimination of all hazards that are totally correctable, and (3) establishment of a control system for any hazardous condition which must remain part of the total process.

Relevant human factors in Bauman's (1974) definition involved taking precautions to prevent, as much as possible, potential consumer abuse. For the food processor/distributor this may mean special packaging materials or label information on use and storage precautions.

HACCP in Foodservice Systems

Bobeng and David (1977) recommended implementation of the HACCP concept for foodservice operations. They developed HACCP quality control models for entrees produced on-premises in conventional, cook-chill, and cook-freeze hospital foodservice systems. A flow diagram for process points for entree production in a conventional system is shown in Figure 1.

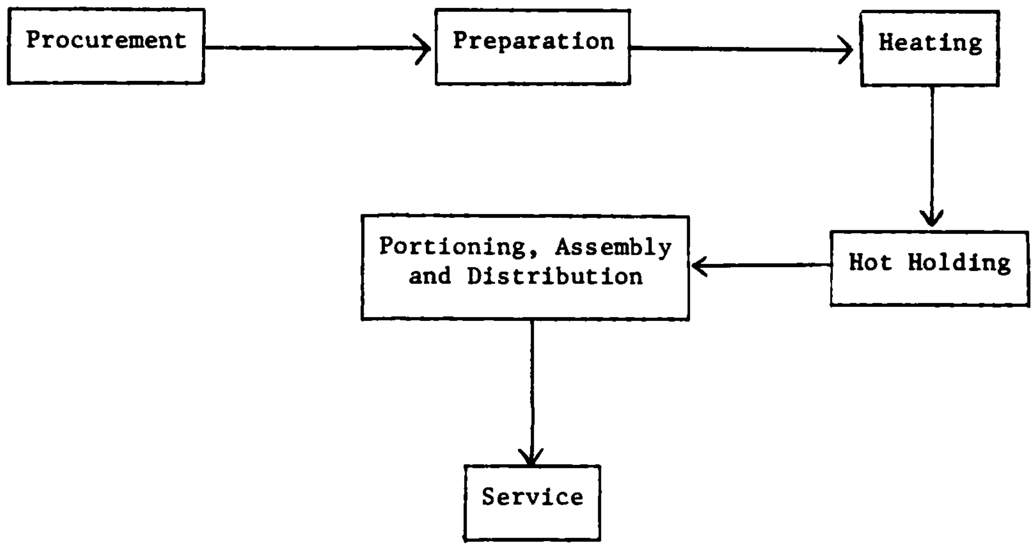

Fig. 1. Process points for entree production in a conventional system.[1]

[1] Adapted from original diagram by Bobeng, B. J. and David, B. D., 1978. I. HACCP models for quality control of entree production in hospital foodservice systems. Journal of the American Dietetic Association. 73:524-529.

Bobeng and David (1978a) identified four critical points foodservice managers must control to eliminate or reduce a microbial hazard: ingredient control and storage, equipment sanitation, personnel sanitation, and time-temperature standards. They also identified which of the four critical management control points needed to be monitored during each phase of product flow (Table 1).

Bobeng and David (1978a) concluded by saying that standards and monitors for managing critical points must be established for each operation based on each system's objectives, resources and constraints.

Bryan (1981) described the steps in conducting a hazard analysis of a foodservice establishment: (1) identify potentially hazardous foods and sensitive ingredients that contain poisonous substances, pathogens, or large numbers of bacteria, and/or that can support microbial growth; (2) find sources and specific points of contamination by observing each step of the operation; (3) determine the potential for microorganisms to survive the heat process; and (4) determine the potential for microorganisms to multiply at room temperature and during hot and cold storage. To control the potential hazards identified in the hazard analysis, Bryan (1982) emphasized the importance of time-temperature relationships, the role of workers and equipment in contaminating cooked food, and the handling and storage of foods after they are cooked.

Time and Temperature Controls

Microbiological testing of ingredients and finished products compared with established microbial limits would seem the ideal way

TABLE 1

CRITICAL MANAGEMENT CONTROL POINTS IN RELATION TO PROCESS POINTS DURING ENTREE PRODUCTION IN A CONVENTIONAL FOODSERVICE SYSTEM[2]

Critical Management Control Points	Process Points: Procurement	Preparation	Heating	Hot Holding	Portioning Assembly, and Distribution	Serving
1. Ingredient control and storage	x					
2. Equipment sanitation		x			x	x
3. Personnel sanitation		x			x	x
4. Time-temperature relationship	x	x	x	x	x	x

[2]Adapted from original table by Bobeng, B. J. and David, B. D., 1978. I. HACCP models for quality control of entree production in hospital foodservice systems. Journal of the American Dietetic Association. 73:524-529.

to control the microbiological safety of food prepared in hospital foodservice systems. However, Peterson and Gunnerson (1974) pointed out that results of microbiologic testing would not be available for corrective action before the menu items were served to patients or customers.

Bobeng and David (1978a) stated that controlling time and temperature at each process point is a practical method for monitoring microbial safety of food during storage, preparation, and service in hospital foodservice systems. Continuous surveillance of time and temperatures provides immediate feedback for management to take corrective action according to Matthews (1982b).

Potential Hazard of Potato Salad

Longree (1980) stated that meat, egg, poultry, and potato salads have been indited in many foodborne gastroenteric episodes. Fowler and Clark (1975) obtained sixty-four delicatessen salads (including potato and several other types) from thirteen manufacturers in ten geographic regions for microbial analysis. The purpose of the study was to examine the data for compliance with Army and Air Force Exchange (AAFES) microbiological limits. Counts obtained from the commercially prepared samples exceeded AAFES limits in 56 percent of the samples.

High bacterial counts in potato salad prepared in selected Army and Air Force foodservice facilities were reported by Silverman et al. (1975a, 1975b). Harris et al. (1975) investigated several types of prepared salads from retail markets and reported high bacterial counts

for potato salad. Pace (1975) reported high bacterial counts in delicatessen salads including potato salad from 150 retail markets. Longree et al. (1959) studied potato and turkey salads. Some formulations of potato salads were found to have higher microbial counts than others.

Inhibitory Effect of pH

A pH of 4.5 or below is generally recognized to inhibit the growth of most pathogenic organisms (Longree, 1980). Smith (1977) found that the pH in commercial salad dressings ranged from 3.2 to 3.9; pH of mayonnaise ranged from 3.0 to 4.1. Wethington and Fabian (1950) found that staphylococci and salmonellae did not multiply and and eventually died when innoculated into mayonnaise and salad dressing. Lerche (1962) observed that when mayonnaise was innoculated with salmonellae and then used in the preparation of meat salad, the meat became invaded by the contaminant. In his review of the microbiology of mayonnaise and salad dressing, Smittle (1977) stated that due to their low pH, mayonnaise and salad dressing are unfavorable media for growth and survival of most bacteria, especially pathogens.

If mayonnaise and salad dressing are unfavorable growth media for pathogens, why have several investigators found potato salad to have unacceptably high microbial counts? According to Longree (1980), although the salads may be acid, the degree of acidity varies greatly with formulation. In addition, due to numerous steps of chopping, mixing, and handling ingredients, chances are excellent for various ingredients to become contaminated with pathogens clinging to chopping

boards, knives, choppers, and human hands. Longree (1980) stated that while mayonnaise or salad dressing may not support growth of pathogens, either could serve as a vehicle of contamination providing that time elapsing between contamination of the dressing and its use in food preparation would be sufficiently short to allow for survival of the contaminants.

Sensory Evaluation

Livingston et al. (1973) reported several factors that affect sensory quality of food: (1) storage time and temperature of raw ingredients, (2) holding peeled vegetables in water until they are used, and (3) delayed service methods such as holding at room temperature. Serving temperature is well recognized as a major factor in sensory acceptance of food (Blaker, 1961). Erdman (1979) reported losses in nutrient and sensory quality of once-cooked plant foods that were held refrigerated for a day or more.

Karlstrom and Jonsson (1977) stated that hot-holding causes the greatest losses of certain sensory attributes. These authors found that foods most affected are potatoes, followed by fish and meat. Hill et al. (1977) reported that since hot-holding is destructive to vegetable quality, these products should not be subjected to more than thirty minutes hot-holding.

Sensory quality of food refers to the measured response of persons to its appearance, flavor, texture, and temperature (Amerine et al., 1965). Much concern has been expressed about the quality (including sensory attributes) of foods produced in the alternate

foodservice systems (Donaldson, 1971); yet only limited information on sensory quality of food produced in conventional systems is available for comparison.

In Commissary and Ready-Prepared Systems

Cremer and Chipley (1980b) reported on the sensory evaluation of scrambled eggs prepared in a cook-chill hospital foodservice operation and reheated in microwave ovens. Although the data indicated "good" general acceptability, there were significant differences both among the three trials and between the three galleys studied. The differences appeared to be directly related to the variability in internal temperatures after heating the eggs for service.

Overall sensory quality of meatloaf served in a commissary system rated a mean score of 6.6 on a 9-point scale (Cremer and Chipley, 1979). The authors noted that although this score was acceptable, sensory quality may be improved if meatloaves were prepared on the same day of service. Cremer and Chipley (1977) reported the mean sensory quality rating of precooked, frozen hamburger patties in a satellite system to be 5.5 on a 9-point scale.

Comparison Studies

Cremer (1982) reported a comparison study of sensory quality of scrambled eggs and beef patties reheated in microwave and convection ovens. The data showed that eggs reheated in a microwave oven were scored significantly higher for all characteristics evaluated compared to eggs reheated in the convection oven. Data on the beef patties showed that beef patties reheated in a microwave oven were

scored significantly lower on three of the four sensory characteristics than beef patties reheated in convection ovens. The author suggested that since optimum equipment for reheating seemed to be related to the individual food item, equipment choice should be based on the menu items to be served.

Bobeng and David (1978b) reported the results of a sensory evaluation of beef loaves prepared in conventional, cook-chill, and cook-freeze foodservice systems. Scores for color, flavor, and overall acceptability were significantly higher for the beef loaves prepared in the conventional system. The authors attributed the lower scores for the cook-chill and cook-freeze prepared beef loaves to be due to off-flavors caused by autooxidation.

Zallen et al. (1975) compared the effects of chilled holding on quality of beef loaves. These authors found the beef loaf prepared conventionally to be rated higher in all quality related attributes evaluated.

More data appear to be needed to develop the methodology for achieving high sensory quality of food in the various foodservice systems.

CHAPTER III

PROCEDURE

A preliminary observation was made to identify the phases in food product flow in preparation of potato salad in a conventional foodservice system. Actual time and temperature conditions during preparation and service of the potato salad were recorded on three subsequent occasions. Sensory quality of the prepared potato salad was evaluated during each of the three observations using quantitative descriptive analysis (QDA) as described by Stone et al. (1974).

Site Selection

The USAF Medical Center at Wright-Patterson AFB, OH, was a 350 bed general medical regional referral center. Average daily patient census was 280. Proportion of therapeutic diets served was 35 percent. Average number of meals served daily to patients, staff, and visitors was 1200. This conventional foodservice system was typical of that found in the other four USAF regional medical facilities of similar size located throughout the continental United States. The Wright-Patterson site was selected because it was considered representative of similar USAF facilities. Thus, problems or strong points found in this operation might be found in similar USAF facilities.

Product Flow

The phases of food product flow in preparation of potato salad were identified by observation of the operating system (Fig. 2).

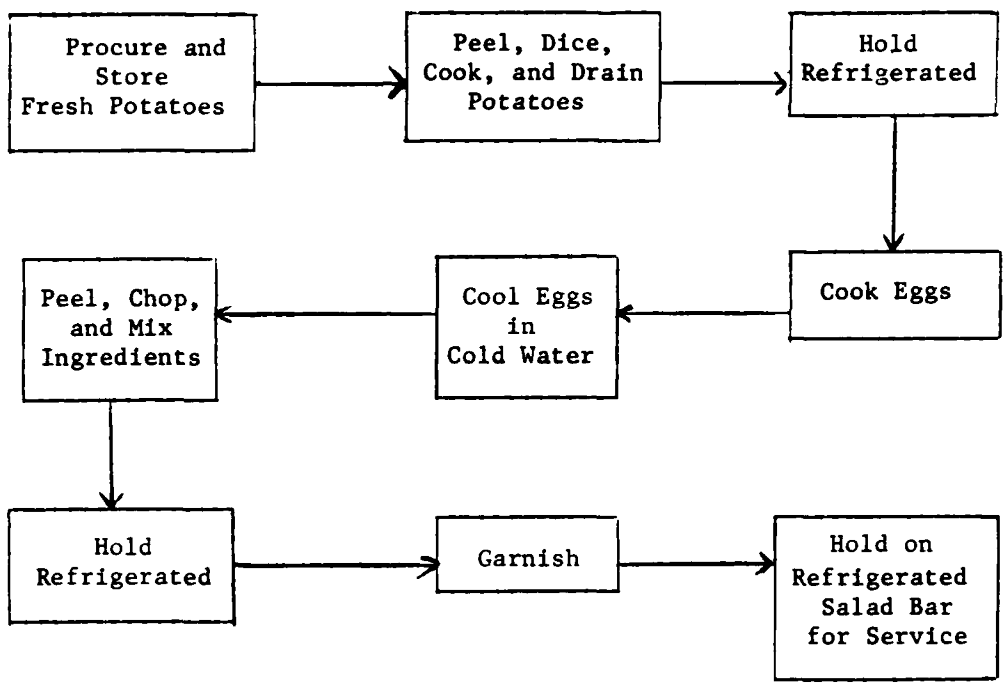

Figure 2. Phases in food product flow in preparation of potato salad.

In the Wright-Patterson Medical Food Service, potato salad was always prepared the morning of service and was always served at the lunch meal. Russet potatoes for potato salad cafeteria service were peeled in a mechanical peeler, diced by hand, and cooked in salted water in an open pot on a burner of a gas range the day before service. Cooked potatoes were drained, spread on an 18 x 36 inch

pan, covered and stored in a walk-in refrigerator until the next morning. On the morning of the day of service, fresh eggs were hard cooked in a Hobart high pressure steamer, cooled under cold running water, peeled, and chopped by hand; fresh onions, green peppers, and celery were chopped by hand; and all ingredients were mixed. The prepared salad was transferred to a 12 x 20 x 4 inch stainless steel counter pan, covered, and stored in a walk-in refrigerator. Later the prepared salad was garnished and placed on the refrigerated self-service salad bar (Carter-Hoffman Mobile Buffet Server Model R-76) for noon meal service.

In Trial 1, 150 portions of potato salad were prepared whereas only 100 portions were prepared in Trials 2 and 3. The additional 50 portions prepared in Trial 1 were served at a catered picnic outside the cafeteria. The entire batch of potatoes required for each trial was cooked in one large pot on the day before service. Thus, in Trial 1, the pot was filled to capacity whereas in Trials 2 and 3 the pot was not completely filled.

In each trial a copy of the standardized recipe for potato salad (Appendix A) was attached to the daily production worksheet for easy reference of the foodhandler preparing the salad. In Trial 1 the recipe amounts had been increased by the foodservice supervisor before posting to the daily worksheet. Instructions were also written concerning use of the additional 50 portions.

A total of three different foodhandlers were involved in the preparation of potato salad for this study. The first foodhandler peeled, diced, cooked, drained, covered, and refrigerated the

potatoes used in each of the three trials on the day before service. The second foodhandler prepared the salad in Trial 1. The third foodhandler prepared the salad in Trials 2 and 3.

Since one of the objectives of this study was to record time-temperature data under actual operating conditions, no attempt was made to regulate food production or service activities. It was noted and recorded in Trial 1 that several delays occurred between various phases in product flow.

The delays involved various ingredients left at room temperature while the foodhandler performed other tasks, was distracted by conversation with other foodhandlers, or took rest breaks. Subsequently, during Trials 2 and 3 when a different foodhandler was assigned to prepare potato salad, no delays between phases in product flow were observed.

Time-Temperature Data Collection

During each of three replications, time-temperature data were collected and recorded according to phases in product flow. Ingredient temperatures were recorded at 30 minute intervals during holding and preparation.

Internal temperatures of food were read with PSG Industries, Inc. pocket type bi-metal thermometers calibrated to be accurate within 2^{o}F. Calibration accuracy was verified by immersing the thermometer stem two inches into ice water for 45 seconds, or immersing the thermometer stem two inches into boiling water for 45 seconds. Internal temperatures of food were read 45 seconds

after inserting the thermometer stem two inches into the food or into the center of the mass if it was more than two inches deep. Three temperature readings were recorded for each pan of food. Readings were taken in the lower right corner, geometric center, and upper left corner of the pan.

Ambient temperatures in the walk-in refrigerator were read from a thermometer located on a wall outside the refrigerator. Temperatures were recorded at 30 minute intervals during refrigerated storage of cooked potatoes, and prepared potato salad, and after overnight refrigerated storage of cooked potatoes. Temperatures in the refrigerated compartment of the self-service salad bar (Carter-Hoffman Mobile Buffet Server Model R-76) were read at 30 minute intervals from an ice water calibrated Acu-Rite Refrigerator-Freezer Thermometer manufactured by John L. Chaney, Co., Lake Geneva, Wisc.

Sensory Evaluation

Using the quantitative descriptive analysis (QDA) method described by Stone et al. (1974), sensory evaluation of potato salad was conducted on three separate occasions under the usual conditions in the staff cafeteria of the USAF Medical Center Wright-Patterson AFB at 11:00 a.m.

Initial Selection and Training of Panel Members

Eighteen prospective taste panel members were identified from among the military dietitians, foodservice supervisors, and foodservice workers at Wright-Patterson USAF Medical Center. Prospective taste panel members were screened for their ability to discriminate

between the following solutions compared to distilled water in a triangle taste test: (a) 0.1% NaCl, (b) 0.2% NaCl, (c) 0.5% sucrose, (d) 1.0% sucrose, (e) 0.005% tartaric acid, (f) 0.01% tartaric acid, (g) 0.03% caffeine, and (h) 0.06% caffeine (Amerine et al., 1965). Each sample was assigned a random three-digit code number (see Appendix B for a sample data collection chart).

Prospective taste panel members were screened for their ability to discriminate various attributes of quality in cooked potatoes and potato salad through further triangle screening tests (Sets #1-5 described below). Tests were conducted as follows with cooked, unsalted, diced potatoes labeled with random three-digit code numbers. Only Russet potatoes (cooked, unsalted, diced, labeled with random three-digit code numbers) were used in Sets #2-5:

Set #1: two samples of a floury texture potato (Russet variety) and one sample of a waxy texture potato (Pontiac variety) all cooked to the same degree of doneness;

Set #2: two samples cooked to usual desired degree of doneness, one sample undercooked by four minutes;

Set #3: two samples cooked to usual desired degree of doneness, one sample overcooked by four minutes;

Set #4: two samples of potato salad prepared according to the standardized recipe (Appendix A) and one sample prepared with 10 percent more vinegar as a test of flavor discrimination;

Set #5: two samples of potato salad prepared according to the standardized recipe and one sample prepared with 20 percent more

salad dressing as a test of consistency judgment (see Appendix C for a sample data collection chart).

Development of Score Sheet

In sensory analysis by quantitative descriptive analysis (QDA) (Stone et al., 1974), a score sheet listing the sensory attributes of a product is developed by the researcher. The score sheet is used by trained individuals to identify and quantify the sensory properties of a product. The perceived sensory attributes of a product are developed by the researcher through introspection. Next, language describing the intensity of each attribute is developed. The pairs of words or expressions are placed at anchor points one-half inch from either end of a six-inch horizontal line. After the judges have evaluated the product by placing a mark at any point on the six-inch line, the researcher converts the marks to numerical scores using a scale of 0-60.

Selection of Taste Panel Judges and Subsequent Training

The seventeen members who scored at least 60 percent correct on each of the screening tests (ASTM, 1968) were asked if they wished to participate in future taste panels to judge the sensory quality of potato salad. Ten panel members who indicated their willingness and their availability to participate in future taste panels were selected as sensory evaluation judges. The ten judges selected were all active duty USAF military members. They included three dietitians, three foodservice supervisors, and four foodservice

workers. Their ages ranged from 19 years to 44 years; years experience in the foodservice field ranged from less than one year to 18 years. Four of the judges were female, six were male.

The sensory evaluation judges were given one practice session and verbal instruction on use of the score sheet (Appendix D). The score sheet incorporated the following features. Each characteristic to be evaluated was followed by a six-inch horizontal line with anchor points one-half inch from each end. One word or expression at each anchor point described the intensity of that attribute. These words or expressions were verbally explained in detail to ensure that each word or phrase had the same meaning for each judge. The taste panel judges were instructed to place a vertical mark on the six-inch line at the point which best reflected their perception of the intensity of that attribute.

Method for Evaluation

As can be seen on the score sheet developed for sensory evaluation of potato salad in this study (Appendix D), for the attributes "amount of dressing" and "consistency of dressing" the score in the midpoint of the scale indicated the highest quality product since the anchor points for these two attributes ranged from "too little--too much" and "too thin--too thick" respectively. Thus, the midpoint of the scale (30 on a 60 point scale) represented the highest quality product. Scores above or below 30 indicated a product of lesser quality.

The highest possible score judges could have given any of the other attributes was 60. However, none of the judges scored any attribute higher than 55 which fell on the vertical line marking the anchor point of the verbal descriptor. Either the judges felt that no characteristic in any of the trials qualified for a score in the far right one-half inch of the scale (55-60 on the 60 point scale) or, due to the panelists' inexperience, they assumed that the anchor point marked the highest point on the scale even though they had been instructed that they could mark any spot on the six-inch line.

During the sensory evaluations, judges were seated at dining tables at a distance from each other to minimize influencing each other. Efforts were made to eliminate distractions and disturbances during the evaluation.

Data Analysis

The time-temperature data collected during preparation and service of potato salad was compiled and is reported as means, ranges and standard deviations in Tables 2-5. The data were then compared to time-temperature standards (HEW, 1978) to establish critical control points.

The line scores given by the sensory evaluation judges were converted to numbers (see Appendix H) by use of a template marked in tenths of an inch (Stone et al., 1974; Zook and Wasseman, 1977). The overall mean scores and standard deviations for each quality characteristic were calculated. Two-way analysis of variance was used to analyze the data by judge and by trial. The standard

F-test (Snedecor and Cochran, 1967) was used to indicate significance ($p < 0.05$).

CHAPTER IV

RESULTS AND DISCUSSION

Phases of product flow in the preparation of potato salad in a conventional foodservice system were identified in a preliminary study. Actual time-temperature conditions during phases of product flow in the preparation of potato salad were recorded for three replications. The mean time-temperature conditions were compared to time-temperature standards (HEW, 1978). Critical control points where a potential microbial hazard may exist were identified. Sensory evaluation of potato salad was conducted on each of the three replications.

Phases of Product Flow

Observations of one total sequence for preparing and serving potato salad were made and recorded. From this information, a flow diagram was developed to identify the path followed by the major ingredients of potato salad through this foodservice system (Figure 2). In the next step of this study, monitoring and recording time-temperature data under actual operating conditions, a refined flow chart as found in the process of data collection was developed (Figure 3).

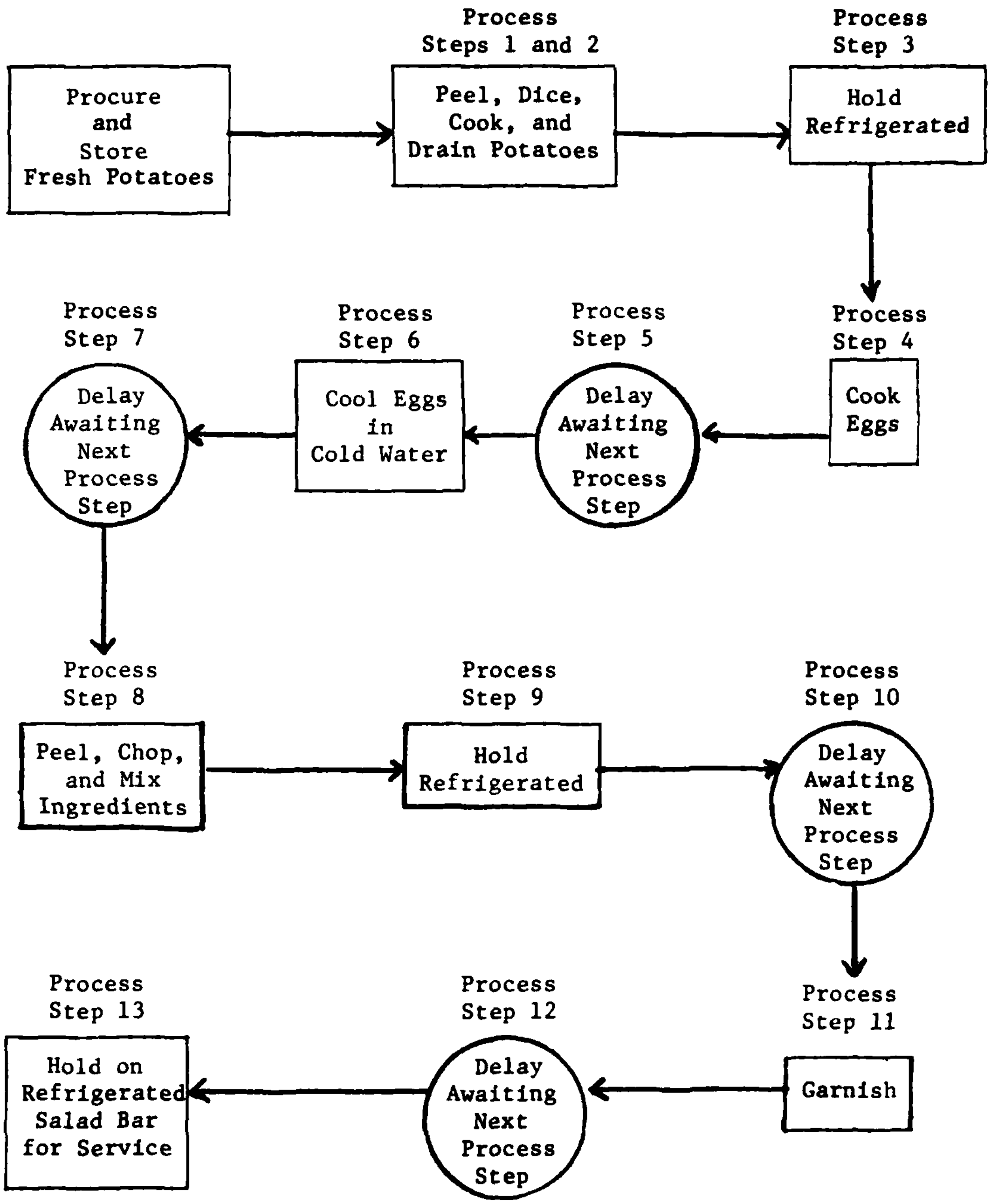

Figure 3. Refined food product flow diagram (labeled process steps) in the production of potato salad.

As can be seen in Appendices E, F, and G, there was a wide range among trials in the time the product was held (0-45 min.) at room temperature in process steps 5, 7, 10, and 12. Since no attempt was made to influence the activities of the foodhandlers preparing potato salad, the wide range of time observed in process steps 5, 7, 10, and 12 can be attributed to the work habits, training and supervision of the individual foodhandler.

Actual Time-Temperature Conditions Compared to Time-Temperature Standards

The second step of this study was to monitor and record actual time-temperature conditions observed during three replications in the preparation of potato salad. The time and temperature means and ranges for three trials for cooking time, holding time at room temperature and during refrigerated storage, and ambient refrigerator temperature are reported in Table 2. The actual time-temperature data for Trials 1, 2, and 3 are reported in Appendices E, F, and G respectively.

Comparison of Time Temperature Data with Time-Temperature Standards

The Food and Drug Administration's (FDA) recommended temperature standards for cooking potentially hazardous food, time-temperature standards for refrigerated storage of foods, and recommended temperature standards for display and service of cold foods are listed in Definition of Terms, p. 7.

TABLE 2. MEANS AND RANGES[a] IN TIME AND TEMPERATURE DATA FOR POTATO SALAD IN VARIOUS PROCESS STEPS IN PHASES OF PRODUCT FLOW.

Process Steps in Phases of Product Flow	TIME (Minutes)					TEMPERATURE (^{o}F)			
	Cooking		Holding, Room Temperature		Holding, Refrigerator	Food		Refrigerator	
	$\bar{X}$	Range	$\bar{X}$	Range		$\bar{X}$	Range	$\bar{X}$	Range
1. Cook Potatoes	68.3	60-85	NA[b]	NA	NA	198.6	188-208	NA	NA
2. Drain Potatoes	NA	NA	18.3	15-20	NA	173.7	159-186	NA	NA
3. Cover and Refrigerate Potatoes[c d]	NA	NA	NA	NA	30	76.7	67-86	48.7	46-50
					60	65.4	58-75	47.3	46-50
					90	57.3	44-70	46.3	46-47
					120	45.3	44-48	44.3	42-46
					15 hr. 30 min.	44.3	43-45	42.6	42-44
4. Cook Eggs	3.5	3.5	NA	NA	NA	190.6	177-203	NA	NA
5. Eggs, Awaiting next process step[c e]	NA	NA	6.6	0-20	NA	162.7	154-169	NA	NA
6. Cool Eggs in cold water	NA	NA	13.3	10-15	NA	91.9	95-118	NA	NA
7. Eggs, Awaiting next process step[c e]	NA	NA	15	0-45	NA	63.3	59-67	NA	NA

TABLE 2 (Continued)

Process Steps in Phases of Product Flow	TIME (Minutes)					TEMPERATURE (^{o}F)			
	Cooking		Holding, Room Temperature		Holding, Refrigerator	Food		Refrigerator	
	$\bar{X}$	Range	$\bar{X}$	Range		$\bar{X}$	Range	$\bar{X}$	Range
8. Chop and Mix all ingredients	NA	NA	90	45-120	NA	62.8	57-69	NA	NA
9. Cover and refrigerate prepared salad[c]	NA	NA	NA	NA	30 60 90[e]	62.8 62.1 60.3	59-66 59-64 59-62	47.3 47.3 46.0	44-52 44-52 46.0
10. Prepared Salad Awaiting next process step[c e]	NA	NA	5	0-15	NA	60.3	59-62	NA	NA
11. Garnish			18.3	10-30	NA	62.1	59-64	NA	NA
12. Garnished Salad awaiting next process step[c e]	NA	NA	5	0-15	NA	61.3	60-62	NA	NA

TABLE 2 (Continued)

Process Steps in Phases of Product Flow	TIME (Minutes)					TEMPERATURE (^{o}F)			
	Cooking		Holding, Room Temperature		Holding, Refrigerator	Food		Refrigerator	
	$\bar{X}$	Range	$\bar{X}$	Range		$\bar{X}$	Range	$\bar{X}$	Range
13. Salad placed in refrigerated buffet server[c]	NA	NA	NA	NA	30	61.9	59-64	31[f]	NA
					60	61.8	59-64		
					90	60.5[g]	58-64		
					120	59.3[g]	58-61		

[a]Means and ranges based on three trials of study; three observations of cooking time; and nine observations for all other values except as noted in Process Step 13.

[b]NA indicates no time or temperature recorded.

[c]Critical control point.

[d]Time and temperature recorded at 30 minute intervals and at the end of overnight storage.

[e]Observed only in Trial 1.

[f]Temperature in the refrigerated buffet serving unit was 31^{o}F throughout the 2 hour period of display and service during all three trials.

[g]Mean is based on six recorded temperatures at 90 minutes and three recorded temperatures at 120 minutes since as diners selected the salad there was insufficient volume in the serving pan to obtain more readings.

Although potatoes are not by themselves a potentially hazardous food, the potatoes used in this study were the major ingredient in potato salad which has been identified as a potentially hazardous food (Fowler and Clark, 1975; Longree et al., 1959; Longree, 1982; Pace, 1975; Silverman et al., 1975a, 1975b). The internal temperature of potatoes (Table 2) after cooking in this study was well above the recommended standard of 140°F and was thus in compliance with the FDA recommendation.

Eggs are a potentially hazardous food. The internal temperatures of eggs after cooking in this study were also well above the recommended standard of 140°F and in compliance with FDA standards.

Since potatoes are not a potentially hazardous food, microbial quality of cooked potatoes may not be significantly affected by the rate of cooling. However, nutritional and sensory quality of cooked potatoes may be compromised by slow cooling rates and refrigerated storage for longer than 24 hours after cooking (Erdman, 1979; Hill, 1979; Karlstrom and Jonsson, 1977). In this study cooked potatoes were cooled rapidly to an internal temperature of 45°F (Table 3) and were served within 24 hours of cooking.

The prepared potato salad is a potentially hazardous food and should conform to the FDA standard of rapid cooling to an internal temperature of 45°F within four hours. The internal temperature during refrigerated storage was always above 45°F in all three trials, however, the potato salad was never held in refrigerated storage for as long as four hours (Table 4). Since the full four

TABLE 3. REFRIGERATOR TEMPERATURES AND TEMPERATURES OF COOKED POTATOES AT VARIOUS TIME INTERVALS DURING REFRIGERATOR STORAGE.

Time	Item	Temperature[a] $\bar{X}$	(°F) Range	Standard Deviation
after 30 min.	Potatoes	76.7	62-86	7.98
	Refrigerator	48.7	46-56	1.89
after 1 hr.	Potatoes	65.4	58-75	5.36
	Refrigerator	47.3	46-50	1.89
after 1 hr. 30 min.	Potatoes	57.3	44-70	8.66
	Refrigerator	46.3	46-47	0.48
after 2 hr.	Potatoes	45.3	44-48	1.25
	Refrigerator	44.3	42-46	1.70
after overnight refrigeration[b]	Potatoes	44.3	43-45	0.66
	Refrigerator	42.6	42-44	0.95

[a]Means and ranges were based on nine recorded temperatures.

[b]Mean overnight refrigeration time was 15 hr. 30 min.

refrigeration time was never reached, this does not indicate either compliance or noncompliance with the FDA standard. Since microbial growth rates are proportional to time held at temperatures favorable for growth, the relatively short holding time (Table 2) between preparation and service reveals an advantage in the conventional foodservice system compared to the alternate foodservice systems.

If the potato salad had been refrigerator stored for the full four hours, the internal temperature of the salad still may not have cooled to 45°F because the ambient storage temperature may not have

been low enough. The observed refrigerator temperature range (44°F-52°F) resulted in a mean temperature above 45°F (Table 2). Therefore, the food held in this refrigerator could not be cooled to the recommended temperature of 45°F. Other researchers have also found high ambient temperatures to be a factor in improper cooling of food (Bunch et al., 1976; Nicholanco and Matthews, 1978; Tuomi et al., 1974; Rollin and Matthews, 1977; Dickerson and Read, 1973). It is false to assume that just because a food item is placed in the refrigerator it is immediately protected against microbial growth (Matthews, 1982b; Rollin and Matthews, 1977). Research has shown, in fact, that microbial growth continues to occur during the slow period of cool down (Tuomi et al., 1974; Dickerson and Read, 1973).

Several other factors besides the relatively high ambient temperature could contribute to a slower than recommended cooling rate. Rollin et al. (1979) developed and tested a mathematical model for predicting rate of cooling of ground beef. The factors used in the equations were: the thermal conductivity, the heat capacity, and density of the food item; the thickness, initial temperature, and surface heat transfer coefficient of the mass; and the ambient temperature. The authors concluded that the ambient temperature in their study should have been below 37°F to achieve the FDA recommended cooling to internal temperature of 45°F within four hours.

The storage load and the steady traffic flow in and out of the walk-in refrigerator used in this study of potato salad undoubtedly contributed to the relatively high ambient temperature readings (Table 4). However, after a ten hour overnight period (7:00 p.m.

to 5:00 a.m.) when the foodservice facility was closed for the night, the coolest ambient temperature recorded for this particular walk-in refrigerator was 42°F. Thus, the cooling capacity of this walk-in unit is not optimal and may not be adequate.

TABLE 4. TEMPERATURES OF THE REFRIGERATOR AND POTATO SALAD DURING HOLDING, AFTER MIXING, AND BEFORE GARNISHING.

Time	Item	Temperature (°F)[a] $\bar{X}$	Range	Standard Deviation
after 30 min.	Salad	62.77	59-66	2.11
	Refrigerator	47.33	44-52	3.40
after 1 hr.	Salad	62.11	59-64	1.59
	Refrigerator	47.33	44-52	3.40
after 1 hr.	Salad	60.3	59-62	1.26
30 min.[b]	Refrigerator	46.0	46.0	0.0

[a]Means and ranges based on nine recorded temperatures.

[b]Observed only in Trial 1.

The recommended temperature (FDA, 1978) of chilled food during display and service is an internal temperature of 45°F or below. As can be seen in Table 5, the temperatures of potato salad during display and service did not meet the recommended standard in any of the trials.

The display and service equipment used in this study was the Carter-Hoffman Mobile Buffet Server Model R-76. The manufacturer's description of this equipment stated that model R-76 is not capable

TABLE 5. TEMPERATURES OF POTATO SALAD AT VARIOUS TIME INTERVALS DURING DISPLAY AND SERVICE AND AT END OF SERVICE.

Temperature of Potato Salad ($^{\circ}$F)	after 30 min.	after 1 hr.	after 1 hr. 30 min.	after 2 hr. (end)
$\bar{X}$	61.89[a]	61.78[a]	61.11[b]	59.88[c]
Range	59-64	59-64	58-64	58-63
Standard Deviation	1.57	1.71	1.97	1.59

[a]Means based on nine recorded temperatures.

[b]Mean based on six recorded temperatures.

[c]Mean based on three recorded temperatures.

of "refrigerating" or reducing the temperature of food placed in its refrigerated compartment. The manufacturer described the model R-76 as being designed to maintain the original chilled temperature of adequately chilled foods placed in its refrigerated compartment. Temperature in the refrigerated compartment of the model R-76 was 31°F throughout the two hour period of display and service for all three trials.

The slightly decreasing mean temperatures of potato salad during display and service (Table 5) indicate that the model R-76 server used was probably at least as effective as the manufacturer's literature claimed it would be in maintaining the temperature of the food. The slightly decreasing temperatures over time can be attributed to a slight cooling effect as the potato salad was selected by diners and the volume in the serving pan decreased.

Although the display and serving temperatures of potato salad did not meet the FDA standard, it was probably not because of an ineffective display unit but could be attributed to the fact that the potato salad was not adequately chilled before it was placed on display for service.

Holding time at room temperature during preparation should be kept to a minimum to preserve microbial and sensory quality (Matthews, (1982b). The FDA (1978) recommended that potentially hazardous food be held in the critical temperature zone ($45^{o}F-140^{o}F$) as little time as possible and only during necessary periods of preparation. Total time at room temperature for the ingredients and the prepared potato salad in this study was 3 hours 25 minutes, 2 hours 35 minutes, and 2 hours 35 minutes for Trials 1, 2, and 3 respectively (Table 2). These holding times at room temperature appeared to be excessive and could be reduced substantially to reflect the true minimum time necessary for preparation.

Identification of Critical Control Points

A total of 183 temperature readings of food were recorded during the three replications. The mean time-temperature conditions as reported in Table 2 were compared to FDA recommended time-temperature standards (HEW, 1978) to determine the critical control points.

Each process step in the preparation of potato salad could be considered a potential critical control point because loss of control at any point may lead to contamination and deterioration of

microbial quality. However, a practical method to monitor those process steps most likely to directly affect microbial safety involves studying actual time-temperature relationships and comparing actual conditions to standard recommendations (Matthews, 1982b; Bauman, 1974; Bryan, 1981; Bobeng and David, 1977, 1978a, 1978b; Peterson and Gunnerson, 1974).

A comparison of actual and FDA recommended time-temperature relationships during phases of product flow in production of potato salad revealed three critical process points. As can be seen in Table 2, process step 3 involved a 20 hour 30 minute holding time in refrigerated storage; and process step 9 involved the refrigerated holding of a potentially hazardous food. The mean ambient refrigerator temperature recorded at almost every time interval (Table 2) duirng these two process steps was above the FDA (1978) recommended temperature standard for chilled food (45^{o}F). Process step 13 involved a two hour period of display and service of a potentially hazardous food where the temperature of the food was above the FDA (1978) standard (45^{o}F). Thus, process steps 3, 9 and 13 are identified as critical control points in preparation of potato salad in this foodservice system based on noncompliance with the FDA (1978) temperature standards.

Although FDA has not specified an exact standard for length of time a potentially hazardous food may be allowed to stand at room temperature during preparation, Matthews (1982b) and Bobeng and David (1978a) recommended that foodservice managers establish definite time standards for their own operations and devise methods

to monitor and assure compliance with those standards. The three observations reported here indicate that in this foodservice operation the holding time at room temperature was excessively long ($\bar{X}$= 2 hours 48 minutes) and should thus be considered a fourth critical control point by management.

Sensory Quality Characteristics of Potato Salad

Quantitative analysis provides considerable information on product characteristics. A score sheet listing the sensory attributes of the product in this study was developed by the researcher through introspection and consideration of product attributes. The sensory quality characteristics considered for potato salad in this study (Appendix D) were: color, amount of dressing, consistency of dressing, moistness, textural consistency, conformation of serving, potato texture, degree of doneness of cooked potatoes, firmness of other vegetable ingredients, presence of off-flavor, and blendedness of flavors.

Sensory Quality Evaluation

Raw scores for sensory characteristics of potato salad by trial and by judge are reported in Appendix H. Mean scores, standard deviations, F-values, probabilities of F, and significant differences ($p < 0.05$) are shown in Table 6. Product characteristics are described in terms of these values.

The mean score for color was well below the midpoint of the scale indicating that the product was considered to be more white

TABLE 6. MEANS[a], STANDARD DEVIATIONS, F-VALUES, PROBABILITY OF F[b] AND SIGNIFICANT DIFFERENCES ACCORDING TO JUDGES AND TRIALS.

Sensory Attributes	Mean	Standard Deviation	F-Value Judge	F-Value Trial	Probability Judge	Probability Trial
Appearance						
color: white--medium yellow	19.20	5.16	1.13	1.95	0.3897	0.1717
amount of dressing: too little--too much	33.03	4.38	1.16	0.89	0.3770	0.4276
consistency of dressing: too thin--too thick	31.30	4.92	1.24	2.18	0.3337	0.1415
Textural Appearance						
moistness: looks dry--looks moist	44.70	8.56	3.35	0.27	0.0140[c]	0.7663
consistency: looks mushy--each component apparent	39.13	11.37	3.24	6.39	0.0162[c]	0.0080[d]
conformation of serving: does not hold shape as portioned--holds shape as portioned	48.93	7.58	8.73	0.41	0.0001[c]	0.6728
Overall Appearance						
low quality--high quality	35.00	11.62	1.61	2.34	0.1862	0.1245
Texture						
potato texture: waxy--mealy	37.30	6.39	1.11	3.84	0.4068	0.0409[d]
degree of doneness of potato: answer either A or B						
A. extremely soft, overcooked--firm but not hard	44.97	9.90	1.01	0.19	0.4688	0.8321

TABLE 6 (Continued)

Sensory Attributes	Mean	Standard Deviation	F-Value Judge	F-Value Trial	Probability Judge	Probability Trial
B. extremely hard, undercooked--firm but not hard	0.0	0.0	0.0	0.0	0.0	0.0
firmness of other vegetable ingredients: soft--crisp	50.80	5.70	12.67	0.01	0.0001[c]	0.9891
Overall Textural Quality of Potatoes and Vegetable						
Ingredients: low quality--high quality	41.86	8.07	2.90	0.99	0.0261[c]	0.3923
Flavor						
presence of off-flavor: strong off-flavor--no off-flavor	45.53	8.64	2.28	1.67	0.0650	0.2160
blendedness of flavors: unblended--well blended	42.00	10.74	3.36	2.74	0.0137	0.0915
Overall Sensory Quality: low quality--high quality	40.23	10.78	2.44	4.07	0.0509	0.0347[d]

[a]Based on 10 scores per trial: total of 30 scores in 3 trials.

[b]$p < 0.05$

[c]Attributes which showed a significant difference among judges ($p < 0.05$).

[d]Attributes which showed a significant difference among trials ($p < 0.05$).

than yellow. The mean ratings for amount of dressing and consistency of dressing (33.03 and 31.30 respectively) were at the midpoint of the scale indicating that the amount of dressing was neither "too much" nor "too little", and the consistency of dressing was neither "too thick" nor "too thin". The judges' mean ratings for moistness and conformation of serving were well above the midpoint of the scale which reveals that the product was more moist than dry and tended to hold its shape as portioned. The mean rating for consistency was somewhat above the midpoint of the scale ranging from "mushy to each component apparent". The appearance of the product was judged to be of medium quality since the mean rating for quality of overall appearance was only slightly above the midpoint of the scale.

The mean score for potato texture was slightly above the midpoint of the scale which indicated that the potato texture was somewhat more mealy than waxy. On degree of doneness of cooked potato, all the judges scored the potatoes on the scale of "extremely soft, overcooked to firm but not hard". The mean score was well above the midpoint of the scale which indicated the potatoes were more firm than soft or overcooked. None of the judges scored any sample on the scale of "extremely hard, undercooked to firm but not hard" indicating that none of the samples were perceived as undercooked. A mean score of 50.8 on the firmness rating of the other vegetable ingredients indicated that the texture of those ingredients was crisp rather than soft since the score was well above the midpoint. The overall quality rating for texture of the potato and other

vegetable ingredients was somewhat above the midpoint of the scale which indicates that the potato salad was of medium quality.

The mean ratings for presence of off-flavor and blendedness of flavors were also somewhat above the midpoint of the scale and thus strong off-flavors were apparently not perceived and the flavors were fairly well blended. The mean score for overall quality of the potato salad was 40.23 on the scale of 0-60. This indicates a product of medium quality.

On some of the sensory attributes there were significant differences among the judges and among the trials. Referring to Table 6, there was a significant difference among judges in ratings for moistness. This difference is unexplained but may reflect a difference in preference of the individual judges. There was a significant difference among the judges and among the trials in ratings of consistency as a factor in textural appearance. This could be due to variation in the size of the potato chunks which were cut by hand and the skill and care of the foodhandler during mixing. The significant difference among judges on the ratings for conformation of serving may reflect a difference of preference among the judges, some of whom may have expected to see a scoop of potato salad retain the neat, completely rounded shape of the scoop as in a scoop of ice cream.

The significant difference among judges in their ratings of the firmness of other vegetable ingredients could have been due to the relative difficulty in assessing this attribute since these vegetables were very finely chopped. The significant difference

among the judges' scores for overall textural quality may reflect their difference of opinion on the importance of the texture of the other vegetable ingredients (celery and green pepper) in determining overall textural quality of the product. There may also have been a difference in opinion of the desired textural qualities such as doneness of potatoes or fineness of the chopped vegetables.

The significant difference among the judges on scores for blendedness of flavors may reflect some individuals' sensitivity to the influence of the relatively high amount of vinegar used in this recipe. Some judges may have detected slight off-flavor in the cooked potatoes since they were stored refrigerated approximately 16-18 hours before service.

The significant difference between the trials in ratings for potato texture may have been due to the difference in cooking time among the trials. Another possible explanation is that the significant difference among the trials may have been due to a difference in the starch component of the three different lots of fresh potatoes used in Trials 1, 2, and 3. The storage time and temperature conditions of the potatoes prior to delivery to Wright-Patterson AFB, which could have affected the starch content of the potatoes, are unknown.

The significant difference among trials on overall sensory quality indicates that the judges perceived the overall product to be different in the three trials. This can likely be attributed to the fact that, although a standardized recipe was available for

the foodhandlers, the ingredients were not actually measured but were approximated in all three trials.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

The purpose of this descriptive study was to identify and define phases in product flow in a conventional foodservice system; to identify actual time and temperature conditions in relationship to phases in product flow; to identify critical control points in relationship to the work of other researchers; and to describe the sensory quality of a food product prepared in a conventional system. Potato salad was selected for study because it presents a potential microbial hazard.

The phases in product flow identified in the preparation of potato salad in a conventional foodservice system were: to procure and store potatoes; peel, dice, cook, and drain potatoes; hold refrigerated; cook eggs; cool eggs in cold water; peel, chop, and mix ingredients; hold refrigerated; garnish; and hold on a refrigerated salad bar for service.

Actual time-temperature conditions during preparation and service of potato salad did conform to the time-temperature standards for the ingredients which were cooked (potatoes and eggs). However, the actual time-temperature conditions during refrigerated storage

of the prepared salad and during display and service of the salad did not conform to the time-temperature standards. The high ambient temperature of the walk-in refrigerator used for storage, the excessively long time ingredients were held at room temperature during preparation, the short amount of time the potato salad spent in refrigerated storage before display and service, and the high product temperature during display and service were significant factors in noncompliance with time-temperature standards.

Based on the relationship of time-temperature conditions compared to time-temperature standards, four critical control points in the preparation of potato salad in a conventional foodservice system were identified: refrigerated storage of cooked potatoes, refrigerated storage of prepared potato salad, display and service of potato salad, and holding time at room temperature.

Characteristics used to evaluate the quality of potato salad included color, amount of dressing, consistency of dressing, moistness, mushiness, ability to hold shape as portioned, texture of potato, degree of doneness of cooked potatoes, firmness of other vegetable ingredients, presence of off-flavors, and blendedness of flavors.

The mean score for overall sensory quality of the potato salad in this conventional foodservice system was 40.23 on a scale of 0-60. This indicates a product of medium quality.

Significant differences ($p < 0.05$) were found among the judges on scores for moistness, textural consistency, conformation of serving, firmness of other vegetable ingredients, overall textural

quality, and blendedness of flavors. The possible reasons for the differences could not be determined in all cases. However, some contributing factors could have been the variation in size of chunks of the hand diced potatoes, and the skill of the foodhandler in careful mixing so as not to mash the ingredients.

Significant differences ($p < 0.05$) were found between the trials on the characteristics of textural consistency, potato texture, and overall sensory quality. Precise explanations for the differences are not possible but the most likely cause was that the foodhandlers did not follow the standardized recipe accurately.

Recommendations

The length of time the temperature of the prepared potato salad remained in the zone of microbial growth (above 45°F for three hours or longer) is of concern. Management could take several steps which could each be expected to contribute to an overall improvement in shortening the length of time the prepared potato salad is held at temperatures above 45°F.

1. The cooling capacity of the walk-in refrigerator used for potato salad storage may be improved with installation of a modern compressor, or the unit may require replacement.

2. The number of items stored in this particular walk-in refrigerator may represent an overload. Some items could be designated for storage in other units which are presently underutilized.

3. The traffic flow during peak preparation times may be lessened by making foodhandlers aware of the need to use trays and carts

to transport items to or from the walk-in to minimize the number of trips and length of time the door is open.

4. The eggs could be hard cooked ahead of time and thoroughly chilled before being added to the potato salad.

5. Other ingredients such as salad dressing could be kept chilled until needed in the final step of preparation.

6. Ingredients such as potatoes and eggs could be kept refrigerated while other ingredients are being assembled, measured, or chopped.

7. Foodhandlers should be educated on the need to get potato salad prepared in minimum time and stored under refrigeration instead of working on four or five different salads simultaneously thereby leaving all the salads at room temperature for long periods.

8. Since overall sensory quality mean scores were not particularly high, further study should be done to determine desired color, flavor, and textural characteristics of potato salad.

9. Overall control of the quality of potato salad could probably be improved by supervisors monitoring more closely the foodhandler's use of measuring utensils and scales and ensuring that the standardized recipe is actually followed.

10. Sanitary techniques in handling foods and equipment should be constantly reinforced.

11. Based on the results of this study, foodservice supervisors and foodhandlers should be made aware of just how slowly food items can be expected to cool especially when kept at room temperature for

prolonged periods and then placed in an overloaded, possibly inadequate refrigerator.

APPENDIX A

STANDARDIZED RECIPE FOR POTATO SALAD

Ingredients	100 Portions	Procedures
potatoes, Russet, A.P.	38-40 lbs.	1. Peel and dice potatoes. Add diced potatoes to salted water. Cover. Bring quickly to a boil. Reduce heat; simmer 15-25 minutes or until potatoes are tender. Drain. Cover and refrigerate for use later.
water	4 gal.	
salt	3 oz.	
onions, fresh, finely minced	3 cups	2. Carefully combine cooked potatoes, chopped onions, peppers, celery, pimentos, eggs, drained relish, and seasonings.
peppers, green, chopped	2 cups	
relish, sweet pickle, drained	1 lb.	
celery, fresh, finely diced	3 lbs.	3. Fold in dressing and vinegar. Garnish, cover and refrigerate until serving time.
pimentos, canned, drained, chopped	12 oz.	
eggs, hard cooked chopped	22	
salt	3 oz.	
pepper, black	½ Tbsp.	
salad dressing	2 qt.	
vinegar	1½ cups	

Appendix A

APPENDIX B

Name ____________________

TASTE PANEL SCREENING TEST

In each set of samples presented, two of the samples are identical and one is different. On the line provided record the number of the different sample in each set.

Set #1:	219,	995,	534	:	________
Set #2:	312,	333,	358	:	________
Set #3:	428,	178,	141	:	________
Set #4:	089,	410,	154	:	________
Set #5:	511,	757,	740	:	________
Set #6:	219,	425,	169	:	________
Set #7:	412,	306,	782	:	________
Set #8:	943,	774,	437	:	________

Appendix B

APPENDIX C

Name ____________________________

TASTE PANEL SCREENING TEST

In each set of samples presented, two of the samples are identical and one is different. On the line provided record the number of the different sample in each set.

Set #1:	615,	342,	798	:	________
Set #2:	991,	638,	579	:	________
Set #3:	261,	818,	466	:	________
Set #4:	322,	879,	512	:	________
Set #5:	425,	734,	314	:	________

Appendix C

APPENDIX D

Name ______________________

Date ______________________

TASTE PANEL SCORE SHEET FOR EVALUATION OF POTATO SALAD

Directions: Please taste the sample and answer each question in sequence, placing a vertical line across the horizontal line at the point that best describes the property in the sample.

Appearance

1) color:

white — medium yellow

2) amount of dressing:

too little — too much

3) consistency of dressing:

too thin — too thick

Textural Appearance

1) moistness; freshness:

looks dry — looks moist

2) consistency:

looks mushy — each component apparent

Appendix D

3) conformation of serving:

does not hold shape as portioned — holds shape as portioned

Overall Appearance

low quality — high quality

Texture

1) potato texture:

waxy — mealy

2) degree of doneness of potato:
answer either A or B below

A

extremely soft, overcooked — firm but not hard

B

extremely hard, undercooked — firm but not hard

3) firmness of other vegetable ingredients:

soft — crisp

Overall Textural Quality of Potatoes and Vegetable Ingredients:

low quality — high quality

Flavor

1) presence of off-flavor:

strong off-flavor — no off-flavor

2) blendedness of flavors:

unblended — well-blended

Overall Sensory Quality

low quality — high quality

APPENDIX E

Appendix E

TIME AND TEMPERATURE DATA FOR POTATO SALAD IN VARIOUS PROCESS STEPS IN PHASES OF PRODUCT FLOW: TRIAL 1.

Process Steps in Phases of Product Flow	TIME (Minutes)			TEMPERATURE (^{o}F)	
	Cooking	Holding, Room Temp.	Holding, Refrigerator	Food	Refrigerator
1. Cook potatoes	85	NA[b]	NA	198, 200, 204	NA
2. Drain potatoes	NA	20	NA	176, 180, 183	NA
3. Cover and refrigerate potatoes[a]	NA	NA	30	79, 83, 85	50
			60	60, 63, 66	46
			90	56, 57, 59	46
			120	46, 46, 44	42
			14 hr. 30 min.	44, 44, 44	42
4. Cook eggs	3.5	NA	NA	196, 201, 203	NA
5. Eggs, awaiting next process step	NA	20	NA	154, 165, 169	NA
6. Cool eggs in cold water	NA	15	NA	98, 106, 113	NA
7. Eggs, awaiting next process step	NA	45	NA	59, 64, 67	NA

APPENDIX E (Continued)

Process Steps in Phases of Product Flow	TIME (Minutes)			TEMPERATURE (^{o}F)	
	Cooking	Holding, Room Temp.	Holding, Refrigerator	Food	Refrigerator
8. Chop and mix all ingredients	NA	45	NA	61, 63, 66	NA
9. Cover and refrigerate prepared salad	NA	NA	30 60 90	60, 63, 66 60, 62, 64 59, 60, 62	46 46 46
10. Prepared salad awaiting next step	NA	15	NA	59, 60, 62	NA
11. Garnish	NA	30	NA	60, 62, 62	NA
12. Garnished salad awaiting next step	NA	15	NA	60, 62, 62	NA
13. Salad placed in refrigerated buffet server	NA	NA	30 60 90 120	60, 61, 62 60, 61, 62 59, 60 59	31[c]

[a] Time and temperature recorded at 30 minute intervals and at the end of overnight storage.

[b] NA indicates no time or temperature recorded.

[c] Temperature of refrigerated buffet server.

APPENDIX F

Appendix F

TIME AND TEMPERATURE DATA FOR POTATO SALAD IN
VARIOUS PROCESS STEPS IN PHASES OF PRODUCT FLOW: TRIAL 2.

Process Steps in Phases of Product Flow	TIME (Minutes)			TEMPERATURE (^oF)	
	Cooking	Holding, Room Temp.	Holding, Refrigerator	Food	Refrigerator
1. Cook potatoes	60	NA[b]	NA	188, 192, 195	NA
2. Drain potatoes	NA	15	NA	167, 175, 186	NA
3. Cover and refrigerate potatoes[a]	NA	NA	30	77, 81, 86	50°
			60	69, 72, 75	50°
			90	65, 68, 70	47°
			120	45, 45, 46	45°
			16 hr.	44, 45, 45	42°
4. Cook eggs	3.5	NA	NA	177, 180, 185	NA
5. Eggs, awaiting next process step	NA	NA	NA	NA	NA
6. Cool eggs in cold water	NA	10	NA	111, 114, 118	NA
7. Eggs, awaiting next process step	NA	NA	NA	NA	NA

APPENDIX F (Continued)

Process Steps in Phases of Product Flow	TIME (Minutes)			TEMPERATURE (°F)	
	Cooking	Holding, Room Temp.	Holding, Refrigerator	Food	Refrigerator
8. Chop and mix all ingredients	NA	120	NA	62, 65, 69	NA
9. Cover and refrigerate prepared salad	NA	NA	30 60	59, 62, 65 59, 62, 63	44 44
10. Prepared salad awaiting next step	NA	NA	NA	NA	NA
11. Garnish	NA	10	NA	59, 62, 63	NA
12. Garnished salad awaiting next step	NA	NA	NA	NA	NA
13. Salad placed in refrigerated buffet server	NA	NA	30 60 90 120	59, 62, 62 59, 62, 61 58, 60 58	31[c]

[a]Time and temperature recorded at 30 minute intervals and at the end of overnight storage.

[b]NA indicates no time or temperature recorded.

[c]Temperature of refrigerated buffet server.

APPENDIX G

Appendix G

TIME AND TEMPERATURE DATA FOR POTATO SALAD IN
VARIOUS PROCESS STEPS IN PHASES OF PRODUCT FLOW: TRIAL 3.

Process Steps in Phases of Product Flow	TIME (Minutes)			TEMPERATURE (^oF)	
	Cooking	Holding, Room Temp.	Holding, Refrigerator	Food	Refrigerator
1. Cook potatoes	60	NA[b]	NA	197, 206, 208	NA
2. Drain potatoes	NA	20	NA	159, 164, 170	NA
3. Cover and refrigerate potatoes[a]	NA	NA	30	62, 67, 70	46
			60	58, 61, 65	46
			90	44, 47, 50	46
			120	44, 44, 48	46
			16 hr.	43, 45, 45	44
4. Cook eggs	3.5	NA	NA	187, 190, 196	NA
5. Eggs, awaiting next process step	NA	NA	NA	NA	NA
6. Cool eggs in cold water	NA	15	NA	95, 97, 102	NA
7. Eggs, awaiting next process step	NA	NA	NA	NA	NA

APPENDIX G (Continued)

Process Steps in Phases of Product Flow	TIME (Minutes)			TEMPERATURE (°F)	
	Cooking	Holding, Room Temp.	Holding, Refrigerator	Food	Refrigerator
8. Chop and mix all ingredients	NA	105	NA	57, 59, 63	NA
9. Cover and refrigerate prepared salad	NA	NA	30 60	63, 63, 64 62, 63, 64	52 52
10. Prepared salad awaiting next step	NA	NA	NA	NA	NA
11. Garnish	NA	15	NA	63, 64, 64	NA
12. Garnished salad awaiting next step	NA	NA	NA	NA	NA
13. Salad placed in refrigerated buffet server	NA	NA	30 60 90 120	63, 64, 64 62, 64, 6[illegible] 62, 64 61	31[c]

[a]Time and temperature recorded at 30 minute intervals and at the end of overnight storage.

[b]NA indicates no time or temperature recorded.

[c]Temperature of refrigerated buffet server.

APPENDIX H

Appendix H

RAW SCORES[a] FOR SENSORY CHARACTERISTICS[b]
OF POTATO SALAD ACCORDING TO JUDGE AND TRIAL

Judge	Sensory Characteristics														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	28	34	29	48	49	54	55	45	55	0	55	55	55	55	55
2	13	32	33	55	55	55	55	31	55	0	55	55	55	55	47
3	24	39	35	46	44	41	29	40	43	0	46	46	29	40	23
4	18	41	30	32	30	30	28	35	37	0	39	30	41	21	22
5	23	32	30	41	55	55	44	46	46	0	55	49	32	32	42
6	19	34	32	54	45	42	26	35	22	0	53	30	45	50	40
7	12	32	24	32	44	31	28	35	31	0	36	31	39	31	25
8	19	33	25	50	40	53	22	44	54	0	54	33	41	54	46
9	20	35	41	47	33	54	32	50	54	0	54	31	50	25	26
10	15	29	28	55	55	53	30	50	55	0	55	40	55	20	26
1	13	30	29	34	31	52	32	34	43	0	55	49	32	51	48
2	13	33	24	55	55	55	50	34	55	0	55	55	55	55	55
3	24	32	31	40	40	44	36	34	39	0	43	34	34	43	34
4	19	25	32	33	30	44	30	39	40	0	39	37	40	38	33
5	16	38	25	46	26	55	18	29	45	0	55	49	41	37	47
6	18	37	35	35	26	41	23	40	50	0	52	46	46	40	44
7	18	26	31	45	26	48	32	31	33	0	50	34	41	32	27
8	15	32	23	41	25	54	31	30	39	0	54	39	55	49	53
9	25	37	35	52	25	52	23	42	39	0	51	32	30	28	27
10	10	31	32	55	42	55	16	30	55	0	55	47	55	30	30
1	27	31	35	36	31	34	27	31	31	0	55	46	55	37	40
2	23	35	36	55	55	55	55	34	55	0	55	55	55	55	55
3	21	31	25	49	20	52	50	35	51	0	52	42	49	51	50
4	31	32	32	32	37	41	42	36	54	0	46	41	53	51	48
5	12	25	35	30	45	55	29	29	31	0	51	37	44	43	32
6	20	40	41	49	45	50	41	46	48	0	49	42	46	42	43
7	21	29	39	48	41	52	52	32	53	0	42	44	50	50	50
8	16	43	26	53	22	52	42	47	53	0	55	36	38	53	53
9	20	31	31	54	47	54	47	35	54	0	53	49	50	47	47
10	23	32	35	39	55	55	25	40	29	0	55	42	55	45	39

[a]Scale of 0-60.

[b]A = color
B = amount of dressing
C = consistency of dressing
D = moistness
E = textural consistency
F = conformation of serving
G = overall appearance
H = potato texture
I = potatoes, overcooked or well done
J = potatoes, undercooked or well done
K = firmness of other vegetable ingredients
L = overall textural quality
M = absence of off-flavor
N = blendedness of flavors
O = overall sensory quality

APPENDIX I

Appendix I

MEAN SCORES[a] FOR SENSORY CHARACTERISTICS[b] OF POTATO SALAD

Judge	Mean Scores for Sensory Characteristics														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	23	31	31	39	37	47	38	37	43	0	55	50	47	41	36
2	16	33	31	55	55	55	53	33	55	0	55	55	55	55	52
3	23	34	30	45	35	46	38	36	44	0	47	41	37	45	36
4	23	33	31	32	32	38	33	37	44	0	41	36	45	37	34
5	17	32	30	39	42	55	30	35	31	0	54	45	39	37	40
6	19	37	36	46	39	44	30	40	40	0	51	39	46	44	42
7	17	29	31	42	37	44	37	33	39	0	43	36	43	38	34
8	17	36	25	48	29	53	32	27	49	0	54	36	45	52	51
9	22	34	36	51	35	53	34	42	49	0	53	37	43	33	33
10	16	31	32	50	51	54	24	40	46	0	55	43	55	32	32

[a]Based on three trials and a scale of 0-60.

[b]A = color
B = amount of dressing
C = consistency of dressing
D = moistness
E = textural consistency
F = conformation of serving
G = overall appearance
H = potato texture
I = potatoes, overcooked or well done
J = potatoes, undercooked or well done
K = firmness of other vegetable ingredients
L = overall textural quality
M = absence of off-flavor
N = blendedness of flavors
O = overall sensory quality

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